



# Mississippi State UNIVERSITY

## Center for Air Sea Technology

### FY95 RESEARCH PROGRAM

by

Lanny A. Yeske and James H. Corbin

Technical Report 95-2

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TECHNICAL REPORT 95-2

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CENTER FOR AIR SEA TECHNOLOGY  
FY95 RESEARCH PROGRAM**

by

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## ABSTRACT

The Mississippi State University (MSU) Center for Air Sea Technology (CAST) began operation in FY93 under a two-year research grant from the Office of Naval Research (ONR) Navy Ocean Modeling and Prediction Program (NOMP). In FY95, MSU CAST was awarded five follow-on research grants by ONR. This document reports on MSU CAST performance in these areas of:

- High Resolution Coastal Model Studies;
- A Unified Air Sea Visualization System;
- Relocatable Numerical Coastal Model;
- Participation in DAMEE-North Atlantic Basin; and
- Model Development for Fleet Applications.

Also included is a report on other research grants/contracts CAST had with the Naval Research Laboratory, the Naval Oceanographic Office, the Army Corps of Engineers, and Gulf Weather Corporation. Finally, this report summarizes for FY95 CAST publications, presentations and demonstrations, sponsored seminars, professional recognition, interdisciplinary activities, workshops and meetings attended, and submitted proposals/contracts awarded.

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## 1.0 INTRODUCTION

The Mississippi State University (MSU) Center for Air Sea Technology (CAST) evolved from the Institute for Naval Oceanography's (INO) Experimental Center for Mesoscale Ocean Prediction (ECMOP) which was started in 1989. MSU CAST subsequently began operation on 1 October 1992 under an Office of Naval Research (ONR) two-year grant which ended on 30 September 1994. In FY95 MSU CAST was successful in obtaining five additional research grants from ONR, as well as several other research contracts from the Naval Oceanographic Office via NASA, the Naval Research Laboratory, the Army Corps of Engineers, and private industry.

In the past, MSU CAST technical research and development has produced tools, systems, techniques, and procedures that improve efficiency and overcome deficiency for both the operational and research communities residing with the Department of Defense, private industry, and the university ocean modeling community. We continued this effort with the following thrust areas:

- To develop advanced methodologies and tools for model evaluation, validation and visualization, both oceanographic and atmospheric,
- To develop a system-level capability for conducting temporally and spatially scaled ocean simulations driven by or are responsive to ocean models, and take into consideration coupling to atmospheric models,
- To continue the existing oceanographic/atmospheric data management task with emphasis on distributed databases in a network environment, with database optimization and standardization, including use of Mosaic and World Wide Web (WWW) access, and
- To implement a high performance parallel computing technology for CAST ocean models.

The CAST approach employs the most recent technological advances in database management, graphics/visualization, and network communications including the WWW. CAST deliverables include:

- Implementation of a laboratory-like capability for oceanographic and atmospheric model evaluation and validation that incorporates measurements of performance skill,
- Development of high resolution coastal models based on DieCAST,

- An economical data access solution and distributed database capability for networked database users (including DOD components),
- New model visualization and animation tools for analyzing and assessing model output, and
- Development and implementation of network file browsing capability and use of Mosaic and the WWW for general database access and educational applications.

This technical document reports on the results of the research conducted in FY95 and planned for FY96. In particular, in Section 2.0 we discuss the research conducted with ONR, Section 3.0 with Naval Oceanographic Office, Section 4.0 with Naval Research Laboratory, Section 5.0 with the Army Corps of Engineers, and Section 6.0 with Gulf Weather Corporation. This is followed by Appendix I which summarizes for FY95 CAST publications; presentations and demonstrations; sponsored seminars; sponsored workshops and meetings; professional recognition and awards; interdisciplinary activities; workshops and meetings attended; and submitted proposals/contracts awarded.

## 2.0 FY95 RESEARCH PROGRAM WITH ONR

For FY95 ONR funded the following five projects:

- High Resolution Coastal Model Studies (\$200K)
- A Unified Air-Sea Visualization System (\$251K)
- Relocatable Numerical Coastal Models (\$132K)
- CAST participation in DAMEE-North Atlantic Basin (\$60K)
- Model Development for Fleet Applications (\$350K)

### 2.1 High Resolution Coastal Model Studies Project

The MSU DieCAST (Dietrich/Center for Air Sea Technology) and SOMS (Sandia Ocean Modeling System) models have proved to be accurate and robust in application to small-scale near-coast features. With the Navy's emphasis on coastal and shallow water regions, there is a need for high resolution models that realistically and efficiently simulate coastal ocean dynamics, including density fields and tidal effects.

No existing model can do it all. The Navy Layered Model is ideal for deep water applications. Sigma coordinate models are good for shallow regions, but are less accurate and robust in applications with strong baroclinic pressure gradient effects in regions of large amplitude topography. These effects include shelfbreak fronts and spurs across shelfbreaks which dynamically couple shallow and deep water flows. Most models require smoothed shelfbreak topography and/or unphysically large diffusivities for numerical stability. These requirements sacrifice accuracy in representing nature. Thus, there is need for a good intermediate model to bridge the gap between shallow and deep water models.

The DieCAST Model is slightly preferred in coastal applications because its modified Arakawa "a" grid has advantages with curvilinear coordinates. The latter can enhance model efficiency and accuracy in addressing coastal flows. DieCAST is also well suited to use deep-water or far-field boundary conditions from the Navy Layered Ocean Model in application to highly resolved coastal regions. This alone can provide useful coastal region information, particularly density distribution, needed for acoustic and other applications, because the basic coastal flow is strongly affected by deep water conditions combined with detailed local topographic features. Good information can be derived even without detailed coastal region observations.

Because DieCAST is robust and accurate with small-scale features, and because the Navy Layered Ocean Model is ideally suited for deep water effects, the CAST research effort in FY95 concentrated on model developments and applications to coastal regions, and we accomplished the following:

- 1) Added laterally curvilinear metrics (grid increments, area factors, volume factors) to the new free-surface model equations to make them applicable to general laterally curvilinear grids. The conserved momentum components are the usual latitudinal and longitudinal coordinate quantities, and are not required to be normal to control volume faces, although normal advection velocity components are derived from them. Similarly, latitudinal and longitudinal components of the pressure gradient are derived from local grid-directed components for application to the momentum equations. A modified 9-point elliptic solver, which is required only for the barotropic mode and only when the grid is non-orthogonal, will be developed later depending on funding.
- 2) Coupled the old and new free-surface DieCAST models to a mixed layer model to determine vertical eddy diffusivities.
- 3) Added variable latitudinal and longitudinal spherical coordinate increments to the new free-surface model equations so that an expanding

grid could be used to get high resolution in a given latitude and/or longitude band. This allows efficient modeling of coastal regions by using locally extra high resolution, just as variable layer depths in the present models allows efficient modeling of the surface mixed layer. It also allows increased latitudinal resolution in northern ocean regions. The extra high resolution, if confined to shallow and/or northern ocean regions where it is needed most, has less limiting effect on the time step increment than if it were used everywhere.

In FY96, we plan to accomplish the following:

- 1) Add implicit free-surface treatment to DieCAST. This involves adding an appropriate Helmholtz term to the Poisson equation presently in the model to get an equation for "h"; adding some explicit forcing terms involving h; and adding a small h term to the baroclinic pressure gradient. This task was delayed in FY95 in favor of adding curvilinear metrics to the model, and will be completed in early FY96.
- 2) Couple the new free-surface model to the Navy Layered Ocean model. This will be a nested grid approach. Special attention will be given to use consistent interface (open) boundary conditions between the two models. CAST will also exercise and evaluate the coupled system.
- 3) Add data assimilation and perform model evaluation. CAST will collaborate with researchers at the Naval Postgraduate School in building a full data assimilative nowcast/forecast system. Old and new model evaluation will first be done in the data rich California Bight region. Later, pending additional leveraged funding from the Minerals Management Service and the Canadian government, CAST will also test the model in the data rich LATEX Gulf of Mexico region and the northeastern North Atlantic Ocean in collaboration.

Because DieCAST produces realistic small- and large-scale features, it could be used to improve data assimilation schemes by running it with sufficiently high resolution in real ocean regions to determine correlation length scales appropriate for those regions. It could also be used to determine time averaged flow over small topographic features such as seamounts or around islands knowing only the large scale flow. Such applications would greatly enhance data assimilation and initialization for Navy nowcast/forecast capabilities. This will be the subject of a future proposal to the Navy.

It should be noted that several universities and agencies, both national and international, are now collaborating with CAST on the use and application of the DieCAST model. In particular:

- The Australian Bureau of Meteorology in Melbourne (Dr. Brian Sanderson) is using DieCAST to run simulations in the Australian Current and the Tasman Sea.
- The New Zealand Electric Company is collaborating and funding CAST's Dr. David Dietrich and State University of New York Scientist Dr. Malcolm Bowman for modeling studies of coastal areas using DieCAST.
- The New Zealand University of Otago Marine Science Department (Dr. Philip Mladinov, Chairman) is collaborating with CAST on DieCAST model applications locally.
- The Naval Postgraduate School (Dr. Robert Haney) is collaborating with CAST and funding Dr. Dietrich in modeling the California Current using DieCAST.
- The Naval Postgraduate School (Dr. Alvaro Viudez) is currently running DieCAST in the Western Mediterranean (Alboran Basin) to study the dynamics of a major semi-permanent anticyclonic gyre.
- The Naval Research Laboratory (Dr. Steve Piascek) is collaborating with CAST and funding Dr. Dietrich in applying DieCAST to the North Atlantic Basin, with the model being run on SP-2 and Cray supercomputers.
- The Bedford Institute of Oceanography in Nova Scotia (Dr. Dan Wright) is currently employing DieCAST for eddy resolving North Atlantic climate studies.
- The Memorial University of Newfoundland (Dr. Richard Greatbatch) is using DieCAST for high resolution modeling of the Labrador Sea and the Newfoundland/Labrador Shelf.
- The NOAA Great Lakes Environmental Research Laboratory (Drs. Dmitry Beletsky, William O'Connor, and David Schwab) is collaborating with CAST in conducting numerical simulations of internal Kelvin Waves and coastal upwelling events in the Great Lakes.

- The McGill University (Dr. Charles Lin) is collaborating with CAST in the use of DieCAST for global climate research.
- The Dalhousie University (Dr. Keith Thompson) is collaborating with CAST to add data assimilation to DieCAST for application in Canadian waters.
- The Naval Research Laboratory (Dr. Charles Barron) will be using DieCAST to do some comparisons with the Princeton Ocean Model in Gulf of Mexico simulations in the LATEX region.

## 2.2 A Unified Air-Sea Visualization System Project

CAST and the MSU/NSF Engineering Research Center (ERC) for Computational Field Simulation have been collaborating to improve the visualization of ocean and most recently meteorological data. Earlier we collaborated to develop feature detection, analysis, tracking, and animation capabilities, concentrating predominantly on DieCAST. Given the success of that endeavor, we commenced work on optimizing those feature detection algorithms for meteorological applications, attempting to automatically detect and track such features as the jet stream and hurricanes.

As we have addressed these applications, it has become clear that it would be useful to have a unified domain with which to visualize and analyze the results of the multitude of results from the many different oceanographic and meteorological models.

For various reasons such as to conform to the historical sampling structures, the mathematical complexity of the fluid equations when the locations in three space are not equally spaced, and most oceanographers and meteorologists use computational grids which are for the most part less than optimal in conforming to the geometry of the physical domain. This creates great difficulty when the scientist tries to "collaborate" their model data with scattered observational data, data from another model, or data from a simulation run on a different time or space scale.

Building on the ERC's skill in grid generation, CAST's expertise in data approximation and management, and our proven expertise in naval oceanographic visualization, we began in FY95 to develop a unified visualization system. This system will allow the user to compare the results of various models such as layered ocean models and level ocean models to compare the ability of each in modeling phenomena such as barotropic, baroclinic, or Yanai waves. A unified visualization system will also allow a modeler to compare data from a larger-scale model with a

smaller-scale, higher-resolution model, to at least visually integrate coastal and estuarine models with deeper ocean models. The resulting visualization paradigms will have to handle multiple time scales and multiple space scales, as well as complex physics and geometry.

In early FY95 we began documenting and evaluating the principal gridding structures used in oceanographic and meteorological modeling. We also began development of a unifying grid data structure involving varying degrees of complexity. The two grid structures developed in FY95 were non-boundary conforming and boundary conforming spherical curvilinear grids. In FY96, the plan is to develop a globally-coarse, boundary-conforming spherical curvilinear grid with regions of local refinement for enhanced resolution.

The grids are being computed fully automatically. For the FY95 grid types, the input to the grid generators are topography and section of the geoid to grid. For FY96, the inputs will include (optionally) the actual physical data fields, so that refinements can be based on such factors as the gradients in the data fields.

The output resulting from the grid generation modules are 3D or 4D arrays in the case of the FY95 grids and, in the case of an "embedded" grid, a hierarchical data structure reflecting the dependencies among "parent" and "children" cells.

In FY95, we also developed optimum approximation routines to map data from the original grids to a single, unified grid. We also developed data approximation routines for spherical curvilinear grids. In FY96 we will extend these routines to approximate/interpolate data onto hierarchical or embedded spherical curvilinear grids. As appropriate, new visualization paradigms and routines will be developed in FY96 to meet modelers needs. The major significance of this work is to provide an integrated visualization environment, including multiple models, tactical platforms, contextual information (bathymetry, islands, and coastlines) all in the appropriate resolution for the given view volume.

The visualization toolkit is being developed using the concept of graphical objects and shared memory, so that a visualization can be constructed by using multiple visualization routines. For example, a modeler may want multiple transparent isosurfaces and a rake of pathlines to understand one physical phenomena, but a single isosurface and multiple cutting planes to better understand another. Each "object" (cutting plane, isosurface, tactical platform) only has to be "created" once. This has been shown to improve visualization efficiency and allows application-specific routines to be added easily.

## 2.3 Relocatable Numerical Models of Marginal, Semi-Enclosed, and Coastal Seas Project

A majority of the world's population lives within 100 miles of the world's coastlines and is therefore heavily dependent on the coastal and marginal seas for transportation, food, and recreation. The seas have also become more central to U.S. national security. Therefore a better understanding of the circulation in coastal and marginal seas is assuming increased importance, and once again remotely sensed satellite data and numerical ocean modeling are expected to play an important role in this.

The many steps and logistics of setting-up a relocatable numerical model in a new region of interest are tedious and labor intensive. Much of this effort can be simplified with the modern computer technology. For example, in setting-up a 2-D tidal model one needs to specify the domain, define the model grid and resolution, select the appropriate bathymetry database and extract the data, edit the bathymetry for errors such as opening-up closed channels, select and extract ancillary data such as the International Hydrographic Office (IHO) tidal station data, make sure the stations fall on a grid point over water instead of land, edit the ancillary data to correct errors, define the model boundaries, specify the model boundary conditions, generate the model header files, and generate the model input and initialization files.

All of these steps need to be completed before the model can be run to obtain the first output. This process can consume anywhere from a couple of days to a couple of weeks depending on the complexity of the domain and data. For more complex 3-D data assimilating circulation models there are also other steps. Here the user is also faced with postprocessing the model output and managing it systematically. In this effort, complimentary with the University of Colorado (UC) modeling efforts, CAST is developing and testing appropriate tools under the relocatable modeling environment (RME) with a user-friendly graphical user interface (GUI) that will enable the modeler to rapidly relocate ocean models in any region of the world.

UC has developed a readily relocatable, 2-D, nestable, data assimilating numerical model of tides in marginal and semi-enclosed seas. This model, applied to most seas of naval interest, has shown considerable skill in depicting the tidal sea-surface-height (SSH) in these seas. Also the model output is being used to deduce altimetric SSH in these seas as well from both past (GEOSAT) and present (TOPEX/Poseidon and ERS-1) altimeters. This model has been incorporated into the RME with a user-friendly GUI by MSU CAST and transitioned to NAVOCEANO.

The FY95 effort was to follow-up the 2-D barotropic tidal model with a 2-D Storm Surge and Atmospheric Pressure Response Model that also has applications in altimetry. CAST intends in FY96 to work with a sigma-coordinate based, comprehensive physics 3-D tidal model, with data assimilation, that can be used to provide estimates of tidal current structure, both horizontal and vertical, in marginal and semi-enclosed seas. Again, the basic research will be done at UC and the front-end GUI will be designed and built at CAST and transitioned. The final step is to extend the system and methodology to 3-D numerical circulation models assimilating observational data, including altimetric and in-situ data. This will start in FY96 with completion planned in FY97.

#### **2.4 CAST Participation in DAMEE-North Atlantic Basin Project**

In FY95 CAST participated in the Data Assimilation and Model Evaluation Experiment for the North Atlantic Basin (DAMEE NAB), which will continue throughout FY96. Our effort was focused in dataset development, quality control and archival/distribution to meet DAMEE requirements. The goals were to ensure the availability of the highest quality datasets for DAMEE. The traditional emphasis on efficient data management and data accuracy at CAST is a reflection of our long-term objectives to apply state-of-the-art data management technology and sound data quality measures to accelerate the transition of ocean models.

The project responded to the experience gained during DAMEÉ Gulf Stream Region (GSR), which clearly demonstrated the need for a concerted data quality/management effort involving assimilation, assessment and model output datasets. Data are a controlling factor and a common starting point in the assimilation and evaluation process. Verification datasets are the standard for measuring model performance. All phases of DAMEÉ NAB will produce suspect results if less than close attention is given to the quality of data provided to modeling groups. These data must be representative of the real environment. Suspect assimilation and verification datasets will inevitably lead to questionable results and diminish the value of the experiment as a whole. DAMEÉ NAB modeling groups should not be distracted from their objectives by misgivings regarding data. The formulation of actual data requirements for DAMEÉ NAB were established in 1994. CAST supported DAMEÉ as part of the Data Subgroup in the collection, processing, and quality control of required datasets, particularly topography, MCSST, and transport data.

DAMEÉ GSR demonstrated the advantages of a teamwork strategy for dataset generation. This project for DAMEÉ NAB was coordinated with the University of Southern Mississippi Center for Ocean and Atmospheric Modeling (COAM). We assisted COAM in publishing information about DAMEÉ NAB

datasets within a section of the DAMEÉ newsletters and co-authored a technical report addressing DAMEÉ NAB data.

CAST also processed datasets needed for DAMEÉ NAB. We acquired and extracted for the DAMEÉ domain MCSST data from JPL/NASA. This dataset was also interpolated to the different model grids. While a T and S climatology of the North Atlantic Basin has been developed by Lozier, the domain extended only to the Equator in the south, and CAST assisted in filling the holes with the help of other climatologies. CAST also made available to DAMEE participants a new climatology by Levitus that has been released by NODC.

An accurate bathymetric dataset is critical to any ocean modeling effort. Though the ETOP05 dataset is widely used, it required some corrections in select areas of the oceans. CAST made corrections for the bathymetry for DAMEÉ, conducted a gross check in the shallower regions, and made available the digital tools needed within the RME.

## 2.5 Model Development for Fleet Applications Project

In this project, MSU CAST transitioned to the Naval Oceanographic Office (NAVOCEANO), Fleet Numerical Meteorology and Oceanography Center (FNMOC), and the Tactical Environmental Support System (TESS) several software systems that were primarily developed under 6.1 and 6.2 funding in support of the Navy Oceanographic Modeling and Prediction (NOMP) Program. Additional related software was also developed under funding from the Army Corps of Engineers. The basic premise of the original research was to develop a common working environment in which the ocean modeling research community could develop, evaluate, and validate numerical ocean models as they evolved through various stages of research and development. The environment was to support a common/generic capability for data management, objective and subjective evaluation, graphics and visualization, ease of learning and use, and extensibility. The idea was to create a working environment in which an ocean modeler or analyst could bring any model on short notice to apply the commonly accepted evaluation criteria and methods to evaluate or validate any model. The system would provide ready access to whatever data was needed, provide the capability to mix and match various data sets for model initialization or evaluation, provide the ability to visualize any desired combination of model input/output with any verification data set, pass any output desired to a high quality output device (printers, video, etc.), all via an easily used, intuitive graphical user interface, preferably from the user's desktop.

What evolved were three distinctly different software systems all linked via an integrated relational database management system (RDBMS), each keyed to one

of three primary functions. The first called BROWSER, short for Database Browse System, fulfilled the function of searching through an extensive database to locate and make a preliminary decision on the desirability of a particular data set. The second system, the Interactive Data Editing and Analysis System (IDEAS), fulfilled the function of analyzing and editing vertical profiles of ocean temperature and salinity. The third system, the CAST Model Evaluation System (CMES), fulfilled the final requirement to be able to make objective and subjective comparisons and evaluations of any data set in the database, including ocean model input and output. The CMES contained extensive tools and functions for graphics and visualization as well as functions for interpolating data to a specified grid and for objective evaluation.

The above systems were based on the premise that any information any application needs to store, retrieve, or use data, will be stored as metadata in the RDBMS along with the primary data. This then allows all applications, including the graphical user interface and the data management applications, to be very generic and modular. The current system is built on the Navy Environmental Operational Nowcast System (NEONS) developed by NRL Monterey and extensively enhanced by MSU CAST. This has proven very successful and has gained broad acceptance by the global environmental community. A recent development resulting from this strategy was to apply the same philosophy to relocatable numerical modeling systems. Treating the modeling system as a general application, we have developed a graphical user interface that allows the user to create and edit all the data sets needed to initialize and run a model, and then evaluate the returned output. The first working system is a Relocatable 2-D Tide Model developed in collaboration with the University of Colorado. A second area for application of the relocatability idea is with the Army Corps of Engineers Coastal Engineering Research Center (CERC) at Vicksburg, MS, utilizing their wave and surf model called Real Time Wave Forecasting (RTWF). This project has been fully funded by the Army Corp of Engineers in support of a joint effort called Logistical Over The Shore (LOTS) Project. A prototype version of the RTWF was used in support of a live exercise (LOTS II) and produced excellent results. The RTWF uses the FNMOC basin scale wave model forecast for input to its open boundaries. This is an excellent opportunity to leverage the funds the Army has already expended.

In FY94, MSU CAST began collaborating with NAVOCEANO and FNMOC scientists and determined which systems were most needed for transition. As a result, CAST research in FY95 accomplished the following under the Software Transitions to NAVOCEANO and FNMOC task:

- Adapted the 2-D Tide Model to NAVOCEANO requirements and transitioned

- Began development of a 3-D Tide Model
- Transitioned to FNMOC ISIS BROWSER Version 1.0, a combination of CMES Version 2.0 and BROWSER Version 2.0
- Ported ISIS BROWSER to Solaris Operating System
  - Developed on-line MOSAIC user manual for ISIS BROWSER 1.0 and transitioned
- Began development of ISIS BROWSER 2.0
- Ported the Naval Interactive Data Analysis System (NIDAS) to ORACLE
- Provided profile editing and multi-level polygon selection on NIDAS and NIDAS-C
- Developed MOTIF-based interactive data retrieval and plotting software for NIDAS

- Developed network interface for NIDAS analysts to access NAVOCEANO databases
- Added coastal zone color scanner (CZCS) and drifting buoy data to NIDAS database
- Conducted on-line demonstration and tutorial training on NIDAS for NAVOCEANO personnel.

The second task for FY95 was to continue the port to the TESS platform all the applicable high end graphics and visualization tools developed under the NOMP program to support the ocean modeling research community. This effort was begun in FY94 in collaboration with NRL-Monterey. All these graphics and visualization tools were developed under proprietary graphics languages not compatible with the TESS platform. This effort recoded all the graphics and visualization tools into the "GL" language and modified them as required to work on the new TESS platform that will be available in FY96.

The final element of this second task, also in conjunction with NRL-Monterey, was to develop a weather briefing software package for the X-Graphics Workstation associated with TESS, initially known as Weather Watch. Involved

was the development by CAST of a graphical user interface (GUI) and applications programming interface (API) for interfacing to TEDS. At the end of FY95, the WW Briefing Software, with tools and applications adapted to the TESS workstation, was transitioned as Version 1.0.

In FY96, CAST intends to accomplish the following under these tasks which have been retitled as (1) Ocean Database Management Systems (NIDAS) and (2) TESS/NITES Software Tools:

- Transition ISIS BROWSER Version 2.0 to FNMOC
- Design and begin development of software for model evaluation and model transition to NAVOCEANO to support modeling efforts and Warfighting Support Center (WSC) day-to-day requirements
- Develop relocatable ocean model circulation models
- Transition 3-D Tide Model to NAVOCEANO
- Transition Army CERC RTWF to NAVOCEANO
- Determine the feasibility of integrating the Army CERC RTWF into a unified GUI for both Tides and RTWF
- Transition ENVIS (SGI-based three-dimensional environmental visualization software) to NAVOCEANO
- Develop and transition a real-time bathythermograph (BT) editing capability to NIDAS
- Upgrade NIDAS to support tailored products in the WSC SCIF
- Upgrade and transition the Interactive Data Base Administration (DBA) Tools into NIDAS
- Conduct on-line demonstrations and training on NIDAS for NAVOCEANO personnel
- Recode additional tools and applications for the WW briefing software and transition as Version 2.0 with oceanographic briefing software
- Modify WW such that when the TESS Tactical Environmental Display Station (TEDS) is fully implemented, TEDS data will automatically

update WW briefing graphics based upon schedules set by the operator/forecaster

- Implement CHARTWALL with software that supports automatic product generation as the data is received from TEDS to include product displays of NOGAPS and NORAPS fields, skew charts, wind warnings, and others.

### 3.0 RESEARCH PROJECT WITH NAVAL OCEANOGRAPHIC OFFICE

The objective of the Naval Interactive Data Analysis System (NIDAS) project is to provide NAVOCEANO with an interactive overlay capability for several types of oceanographic, meteorological, and satellite derived data; create 3-D gridded fields of temperature and salinity profiles constructed from a combination of "provinced" data (user derived) and gridded data; and provide a user's manual and training of NAVOCEANO personnel in the new software system.

Under this three phase project, the Phase I tasks were to ingest static databases into a CAST installed EMPRESS/NEONS system; prepare draft and final design/database specification documents; ingest revolving databases into EMPRESS/NEONS (Regional GOODS BT's, regional GOODS buoys, MCSST grids, OOC composites, NAVOCEANO regional OTIS, and NIDAS 3-D T-S fields created by applications programs); design and develop application programs to interactively view and evaluate the OTIS fields by comparison with Horizontal Contours (OTIS), MOODS, GOODS, Polygon Browse, and Bathy/Shoreline data fields; design and develop application programs to interactively view and evaluate OTIS fields by comparison with Province Definition, OTIS/Clim Transect Definition, Synthetic Profiles, and Horizontal Contours (clim) data fields; design and develop additional application programs to provide the capability to interactively view and evaluate the OTIS fields by comparison with Frontal Composites and Satellite Image (SST) data fields; assist NAVOCEANO in interfacing the system to the classified POPS via the LAN to ensure the continuity of NIDAS operational commitments; train NAVOCEANO personnel in NIDAS system operation; and provide informal monthly demonstrations on NIDAS. Phase I was completed in 1994 with funding of \$199,000.

The Phase II effort was to make the system relocatable on short notice to any area of the world of local or regional size. This involved the design and development of additional application programs to provide the capability to interactively view and evaluate the OTIS fields, developing a regional definition interface to establish new analysis regions, ingesting additional databases and

model outputs, and designing and developing interactive software for wave fields. Phase II was completed in late FY95 with funding of \$129,000.

Phase III provides for enhancements and modifications to the systems developed in Phases I and II. This involves the ingestion of new datasets and software changes that are presently not identified by NAVOCEANO. Phase III will be completed in November 1995 with funding of \$75,000.

#### 4.0 RESEARCH PROJECT WITH NAVAL RESEARCH LABORATORY

The objective of the Tactical Oceanography Wide Area Network (TOWAN) project is to provide technical support services in the areas of data management, data acquisition, hardware/software acquisition and maintenance, and personnel training to NRL in their effort to establish a wide area network as a part of the Defense Simulations Internet (DSI).

The first task, Data Acquisition, Ingestion and Management, required assistance to NRL in the acquisition and quality control of TOWAN data sets. Data was maintained within NEONS and stored on magneto-optical read/write media. CAST assisted with systems and data management functions until NRL personnel had been trained. The second task, Development of Ocean Model Testbed Data Sets in Coastal Regions and Semi-Enclosed Seas was to assist in investigating and implementing datasets of interest to NRL. The focus was on environmental data distributed by FNMOC. The third task, Hardware and Software Architecture Procurement, Installation and Maintenance, required procurement of compatible computer hardware equipment and proprietary software necessary for systems, database and graphics support of the TOWAN main network node. The final task, Training and Technical Support, provided services to NRL in database administration, systems administration, application design/development, and software integration.

CAST accomplishments in this project included procured, installed and tested two 60 gigabyte fileserver/magneto-optical jukebox systems for use; installed and tested NEONS and proprietary software (Empress and UNIRAS) on the fileserver for TOWAN access; installed and tested the CMES, IDEAS, and BROWSER in the network fileserver environment for TOWAN user access; completed training of NRL personnel; assisted NRL in re-establishing TOWAN connectivity after their relocation to a new building; installed Oceanographic and Atmospheric Master Library (OAML) on the classified fileserver for TOWAN access; procured, installed, and tested tape backup units; and installed upgrades of CAST software.

This project was funded at a level of \$828,774 through October 1995, after which the contract will terminate.

A second project with NRL involves the development of a Master Environmental Library (MEL) for the Department of Defense. This is a long-range effort to catalog and distribute key environmental data sets via the INTERNET to support the modeling and simulation of tactical environmental scenarios. The basis tasks are to:

- Design, implement, and document a MEL Library Structure (LS) Regional Request Handler,
- Purchase dedicated MEL Hardware for the Air Force Environmental Technical Applications Center (ETAC) Regional and CAST Developmental Sites, and
- Install MEL Software at three regional sites and document. Eleven other sites are to be installed during the three-year period.

Optional tasks associated with MEL include:

- Support NRL in its choice of metadata format and implementation,
- Survey other potential MEL users and assist in defining their data needs, and
- Support the definition and implementation of a MEL/LS simulation applications programming interface.

This project was initially funded at \$60,000 in late FY95. Funding for FY96-98 is approximately \$1,400,000, but add-ons are anticipated.

## 5.0 RESEARCH PROJECT WITH ARMY CORPS OF ENGINEERS

The objective of this project was to develop a prototype GUI for integrated operation of the Army Corps of Engineers Coastal Engineering Research Center Real Time Wave Forecasting System.

The GUI supported interactive user input of CERC-determined criteria for initialization of the SHALWSV, STWAVE, and SURF models and displaying their outputs. The features included were constant resolution-variable dimension computational grid generation; predefined regions; variable start/end time

constraints; boundary conditions; sea state initialization; input files in existing formats; model execution and model run status feedback; horizontal map, sea height/sea state versus time, wave period versus time, and wave direction versus time visual plots; and software hooks for future upgrades. Phase I of this project was completed in FY94. System upgrades were added in FY95. Project funding was approximately \$30,000 in FY95.

## 6.0 RESEARCH WITH GULF WEATHER CORPORATION

The objective is to develop an innovative solution for a unified information structure for a system of automated information tools and methodology to efficiently provide output to oceanographic and meteorological forecast models. A metadata base that concentrates on the recognition of oceanographic and meteorological systems as observed from various satellite sensor systems may lead to improved forecasts, with commercial applications, particularly when areas are cloud covered.

Phase I of this research involved the development of metadata fields using sets of automated information tools. The metadata bases use existing algorithms for browsing, visualization, and diagnostic analysis. New rules, based on the manual identification/analysis system, were developed. From the sequential analysis of specific systems, information on past movement, shape, and intensity changes can be shown. From this information, the driving physical forces affecting these systems can be inferred, providing perhaps a forecasting breakthrough. Phase I was completed in FY94 at a cost of approximately \$53,000.

A Phase II proposal was funded in late FY95 at a level of nearly \$750,000 which involves the actual development of the system. The Phase I results confirmed that the present manual methodology employed by the Navy for analysis and interpretation of oceanographic and meteorological satellite imagery is being rapidly overwhelmed by the volume, type, sophistication, and increasing requirements for products derived from the imagery. The only practical long-term solution to the problem is the use of automated analysis tools for interpretation. A number of these tools are now available or being developed. A generic user-friendly metadata database system based on a preliminary object-oriented software system was designed and a portion of the system tested. Following Phase II, there will be an opportunity to progress to Phase III. Here the small business is expected to use non-federal capital to pursue the commercial applications of the research.

## 7.0 CURRENT FACILITIES AND PERSONNEL

CAST software has been developed using Sun Microsystems and Silicon Graphics Inc. (SGI) workstations in a network configuration. The UNIX operating

system, X-Windows client-server model, and the Open Software Foundation's Motif widget set are the cornerstones. The primary computer languages are "C", Fortran and X-Windows; during the coming year CAST will also develop expertise in "C++", SGI proprietary "GL" and/or "OpenGL".

CAST is heavily invested in state-of-the-art computer hardware including an internal network of Sun Sparc (1's, 2's, 4's, and 10's) and SGI Indigo Extreme Graphics workstations and X-terminals. The network consists of a Sun Sparc 1000 Fileserver integrated with a magneto optical "jukebox" file storage system having a 187 gigabyte capacity on 144 internal platters, and six gigabytes of internal magnetic media storage. Remote users may access any systems on-line using the TELNET utility. Output can be routed to on-line optical disk and video tape recording equipment. Hard copy is available from a variety of printers. Additionally, all administrative and management staff, utilizing a combination of MacIntosh and PC desktop computers are connected to the same network as the scientific and technical staff so that email and files can be readily exchanged.

At present, the Center consists of over twenty permanent staff members including oceanographers, meteorologists, software engineers, fluid dynamicists, mathematicians, programmers, postdoctoral assistants, computer technicians, and administrative personnel. CAST also has an active program with research affiliates (academic faculty) and graduate students from the Tulane University Departments of Computer Science, as well as the MSU NSF-sponsored ERC. In 1994 and 1995, CAST supported 25 graduate and undergraduate students. This included five students through the MSU Cooperative Education Program, as well as students from the University of Southern Mississippi, University of New Orleans, Louisiana Tech University, Oregon State University, Brandeis University, and William Carey College. CAST is presently located in the Mississippi Technology Transfer Center (Building 1103) and the Butler House (Building 2435) of the Stennis Space Center (SSC), a major focal point of federal science, engineering, and technology efforts with nearly 4,000 employees.

## APPENDIX I

### CAST PUBLICATIONS

Dietrich, D.E. (1994). Fine Scale Modeling of Coastal Waters: Separation, Recirculation, and Upwelling. Proceedings of the 41st East Pacific Ocean Conference, Mount Hood, OR, 1 October 1994.

Dietrich, D.E. and D-S. Ko (1994). A Semi-Collocated Ocean Model Based on the SOMS Approach. International J. Num. Methods in Fluids, 19, 1103-1113.

Corbin, J.H. and L.A. Yeske (1994). Summary of Ocean Modeling and Prediction Programs FY94. Office of Naval Research Technical Report 32295-2, December 1994, 21-25.

Dietrich, D.E., A. Mestas-Nunez, M. Bowman, and C.A. Lin (1995). Island Wake Vortices Simulated by the DieCAST Ocean Model, Proceedings of the American Geophysical Union Conference on Circulation of the Intra-Americas Sea, San Juan, Puerto Rico, 22-26 January 1995

Dietrich, D.E., A. Mestas-Nunez, C.A. Lin, and D.S. Ko (1995). High Resolution Numerical Studies of Loop Current, Frontal, and Parasitic Eddies in the Gulf of Mexico, Proceedings of the American Geophysical Union Conference on Circulation of the Intra-Americas Sea, San Juan, Puerto Rico, 22-26 January 1995.

Kantha, L.H., P.E. Pontius, and V. Anantharaj (1995). On-line Hypertext Technical Document "Tides in Coastal and Semi-Enclosed Seas." URL <http://www.cast.msstate.edu/Tides2D>.

Stein, C.S., V. Anantharaj, R. Krishnamagaru, M.S. Baer, and J.E. Kent (1995). A Prototype Distributed Master Environmental Library. Proceedings of the Fourth Conference of The Oceanography Society, Newport, RI, 18-21 April 1995.

Hodges, J., S. Ramanathan, and S. Bridges (1995). Re-Engineering a Relational Database System to Produce a Prototype Object-Oriented Database System. Mississippi State University Center for Air Sea Technology Technical Report 95-1, 20 June 1995, 20 pp.

Greatbatch, R.J. and D.E. Dietrich (1995). A High Resolution Model of the Labrador Sea and the Newfoundland/Labrador Shelf. Proceedings of the Conference of IAPSO XXI General Assembly, Honolulu, HI, 19 September 1995.

Anand, H. And R.M. Moorhead (1995). A Unified Air-Sea Visualization System: Survey on Gridding Structures. Mississippi State University Center for Air Sea Technology Technical Report 95-3, 30 September 1995, 17 pp.

Yeske, L.A. (1995) Editor. 1995 Student Research Projects, Mississippi State University Center for Air Sea Technology Technical Note 95-1, 30 September 1995, 20 pp.

Yeske, L.A. and J.H. Corbin (1994). FY95 Research Program. Mississippi State University Center for Air Sea Technology Technical Report 95-2, 30 September 1995, 43 pp.

Bowman, M.J., D.E. Dietrich, and C.A. Lin (1995). Observations and Modeling of Mesoscale Ocean Circulation Near Small Isolated Islands. Small Island Oceanography, AGU Coastal and Estuarine Studies Series, Edited by George Maul. (Under Review.)

Dietrich, D.E., C.A. Lin, A. Mestas-Nunez, and D.-S. Ko (1995). A High Resolution Numerical Study of Gulf of Mexico Fronts and Eddies. Journal of Geophysical Research Special Issue on Gulf of Mexico Eddies. (Under Review.)

Dietrich, D.E. and D.-S. Ko (1995). A Numerical Study of Shelfbreak Effects in the Western Gulf of Mexico. Journal of Geophysical Research Special Issue on Gulf of Mexico Eddies. (Under Review.)

Dietrich, D.E., M.J. Bowman, C.A. Lin, and A. Mestas-Nunez (1995). Numerical Studies of Small Island Wakes. To be submitted to Geophys. Astrophys. Fluid Dynamics. (Under Review.)

Dietrich, D.E. (1995). Parameter Sensitivity Studies in the Gulf of Mexico. Invited Contribution to Appear in: Coastal Ocean Prediction, C.N.K. Mooers, Editor. CRC Press, Boca Raton, FL. (Under Review.)

Dietrich, D.E. (1995b). Reynolds Number and Resolution Sensitivity Studies with Gulf of Mexico Eddies. Journal of Geophysical Research. (Under Review.)

Foster, M.S. (1995). Tactical Oceanography Wide Area Network (TOWAN) Research Program. Mississippi State University Center for Air Sea Technology Technical Report 95-4. (In Preparation.)

## CAST PRESENTATIONS AND DEMONSTRATIONS

Corbin, J.H. (1994). CAST Software Applications. Demonstration to Drs. Robert Zalkan and Russell Groshans, Naval Research Laboratory Backgrounds Data Center, Stennis Space Center, MS, 4 Oct 1994.

Krishnamagaru, R. and L.A. Yeske (1994). CAST Software Applications. Demonstration to Captain Robert Mason of the Naval Tactical Doctrine Command, Stennis Space Center, MS, 12 Oct 1994.

Krishnamagaru, R. (1994). CAST Weather Watch Software Application. Demonstration to Captain Rick Hillyer of SPAWARS, Stennis Space Center, MS, 13 Oct 1994.

Minton, D. of SPAWARS (1994). CAST Weather Watch Software Application. Demonstration to RADM P. Gaffney, Commander Naval Meteorology and Oceanography Command, Stennis Space Center, MS, 14 Oct 1994.

Dietrich, D.E. (1994). Application of the SOMS Ocean Model to Regions with Wide Open Boundaries. Physical Oceanography and Meteorology Seminar Series, Dalhousie University, Halifax, Nova Scotia, Canada, 20 October 1994.

Krishnamagaru, R. and L.A. Yeske (1994). CAST Software Applications. Demonstration to Mr. Robert Peloquin of ONR and Harvard University Modeling Group, Stennis Space Center, MS, 25 Oct 1994.

Krishnamagaru, R. and L.A. Yeske (1994). CAST Software Applications. Demonstration to Army Corps of Engineers Coastal Engineering Research Center and Naval Oceanographic Office Personnel, Stennis Space Center, MS, 25 Oct 1994.

Corbin, J.H. (1994). Metadata Database for Oceanographic Imagery under the Small Business Innovative Research Program. Presentation to CDR David Martin and Mr. Philip Blysmo of the Naval Oceanographic Office Warfighting Support Center, Stennis Space Center, MS, 10 November 1994.

Corbin, J.H. (1994). Metadata Database for Oceanographic Imagery under the Small Business Innovative Research Program. Presentation to RADM Paul Gaffney, Dr. Don Durham, and CAPT Donald Mautner, Commander Naval Meteorology and Oceanography Command, Stennis Space Center, MS, 14 November 1994.

Corbin, J.H. (1994). Recent CAST Software Applications. Demonstration to CDR David Markham and Dr. Edward Harrison of SPAWARS, Stennis Space Center, MS, 15 November 1994.

Dietrich, D.E. (1994). High Resolution Numerical Simulation of Loop Current, Frontal, and Parasitic Eddies in the Gulf of Mexico. Topics in Atmospheric and Oceanic Sciences Seminar, State University of New York, Sunnybrook, NY, 22 November 1994.

Lau, Y. (1994). CAST Software Applications. Demonstration at Next Generation Computer Resources Database Integration Standards Meeting, Orlando, FL, 28-30 November 1994.

Corbin, J.H. and R. Krishnamagaru (1995). CAST Software Transitions to Naval Oceanographic Office. Presentation at 6.4 Program Review by Space and Naval Warfare Systems Command, Stennis Space Center, MS, 5 January 1995.

Corbin, J.H. and R. Krishnamagaru (1995). CAST Software Transitions to Fleet Numerical Meteorology and Oceanography Center and Tactical Environmental Support System, Presentation at 6.4 Program Review by Space and Naval Warfare Systems Command, Monterey, CA, 20 January 1995.

Dietrich, D.E., A. Mestas-Nunez, M. Bowman, and C.A. Lin (1995). Island Wake Vortices Simulated by the DieCAST Ocean Model, Presentation at American Geophysical Union Conference on Circulation of the Intra-Americas Sea, San Juan, PR, 22-26 Jan 1995.

Dietrich, D.E., A. Mestas-Nunez, C.A. Lin, and D.S. Ko (1995). High Resolution Numerical Studies of Loop Current, Frontal, and Parasitic Eddies in the Gulf of Mexico, Presentation at American Geophysical Union Conference on Circulation of the Intra-Americas Sea, San Juan, Puerto Rico, 22-26 January 1995.

Corbin, J.H. and M.C. Ray (1995). Mississippi State University and the Center for Air Sea Technology. Presentation to ADMIRAL James Watkins and Dr. Richard Spinrad, Consortium for Oceanographic Research and Education, Stennis Space Center, MS, 22 February 1995.

Corbin, J.H., H. Anand, and V. Anantharaj (1995). CAST Software Applications. Demonstration to Dr. James Lewis, AARC, and Naval Oceanographic Office Warfighting Support Center Personnel, Stennis Space Center, MS, 20 March 1995.

Stein, C.S., V. Anantharaj, R. Krishnamagaru, M.S. Baer, and J.E. Kent (1995). A Prototype Distributed Master Environmental Library. Presentation and

Demonstration at the Fourth Conference of The Oceanography Society, Newport, RI, 18-21 April 1995.

Corbin, J.H.(1995). CAST Progress Under the Master Environmental Library Project. Presentation at Master Environmental Library Workshop, White Sands Missile Range, NM, 24 May 1995.

Foster, M.S. And R. Krishnamagaru (1995). CAST Software Applications. Demonstration to Space and Naval Warfare Systems Command Program Managers, Stennis Space Center, MS, 25 May 1995.

Dietrich, D.E. and R. Haney (1995). Modeling of the California Current using DieCAST. Presentation to Mineral Management Service Personnel, Scripps Institute for Oceanography, LaJolla, CA, 1 June 1995.

Anand, H. (1995). CAST NIDAS, BROWSER, and CMES Applications. Demonstration to Naval Postgraduate School Personnel, Monterey, CA, 13 June 1995.

Anand H. (1995). ISIS BROWSER Application. Demonstration to FNMOC and NRL Personnel, Monterey, CA 15 June 1995.

Anand, H. (1995). Environmental Visualization Software Application. Demonstration to NRL Personnel, Monterey, CA, 15 June 1995.

Corbin, J.H. (1995). CAST Research Program. Presentation to MSU Vice President for Research and Director Centers and Institutes at Annual Management Review, Stennis Space Center, MS, 27 June 1995.

Corbin, J.H. (1995). CAST Software Applications (Model Evaluation System, ENVIS, and Weather Watch). Presentation and demonstration to NAVOCEANO Warfighting Support Center Personnel (LCDR Bud Dailey, Michael Brooking, Mark Booda, and David Cole), Stennis Space Center, MS, 17 July 1995.

Corbin, J.H. (1995). CAST Software Applications (Verification Module). Presentation and demonstration to NAVOCEANO Warfighting Support Center Personnel (Mark Booda and David Cole), Stennis Space Center, MS 25 July 1995.

Dietrich, D.E. (1995). A Low Numerical Dissipation Ocean Model Applied to the Gulf of Mexico and North Atlantic Ocean. Seminar for the Center for Nonlinear Study Conference, Los Alamos National Laboratory, Los Alamos, NM, 25 July 1995.

Corbin, J.H. (1995). CAST Software Applications. Demonstration to Physitron, Inc. Personnel, MSU/NSF Engineering Research Center, Mississippi State, MS, 16 August 1995.

Corbin, J.H., R. Krishnamagaru, and V. Anantharaj (1995). CAST Research Progress in Support of the Master Environmental Library. Presentation and demonstration to NRL Managers, Monterey, CA, 5 September 1995.

Foster, M.S. (1995). CAST Research on NEONS and NETNEONS Development. Presentation to FNMOC and NRL Program Managers, Monterey, CA, 8 September 1995.

Corbin, J.H. and L.A. Yeske (1995). CAST Research Program. Presentation to MSU Centers and Institutes Special Panel on Program Review, Mississippi State, MS, 14 September 1995.

Corbin, J.H. (1995). CAST Software Applications. Presentation and demonstration to Naval Oceanographic Office IDBMS Project Manager Jeffrey Mosley, Stennis Space Center, MS, 29 September 1995.

#### SEMINARS SPONSORED BY CAST

Name/Institution	Title	Date
Krishna Achutarao, Ph.D. Laitram Corporation New Orleans, LA	Variability of Ocean Surface Heat Flux and Poleward Heat Transport Using the COADS Data Set	23 Mar 95 SSC, MS
Zhifan Zhu, PhD. Engineering Res Center Mississippi State Univ	Extracting and Visualizing Ocean Eddies in Time-Varying Flow Fields	29 Mar 95 SSC, MS
Shekar Ramanathan Computer Science Dept Mississippi State Univ	An Object-Oriented Prototype Database for Grid Data	31 Mar 95 SSC, MS
Avichal Mehra, PhD. Engineering Department University of Virginia Charlottesville, VA	A Control Volume Model for Computation of Flowfields and Hydrodynamic Forces in Gas Seals	30 May 95 SSC, MS
Dorlisa Hommel National Ocean Data Center, NOAA Washington, DC	Simulated Flow over a Seamount Using a Primitive Equation General Circulation Model	18 Sept 95 SSC, MS

## **PROFESSIONAL AWARDS TO CAST PERSONNEL**

To J.H. Corbin, Recognized by Mississippi State University Vice President for Research as one of the top MSU researchers, 29 November 1994

To J.H. Corbin, Nominated for Mississippi State University Alumni Association Outstanding Researcher Award, 23 January 1995

## **CAST PARTICIPATION IN INTERDISCIPLINARY ACTIVITIES**

The MSU Cooperative Education Program. CAST employed three MSU Cooperative Education students (Mr. Clifton Abbott, Mr. Owen Lagarde, Mr. and Mr. Ognen Zagrofski) during this period. Following his graduation, Mr. Abbott was hired by CAST as a Research Assistant I.

The MSU Engineering Research Center (ERC) and College of Engineering. A joint research effort in developing a unified air-sea visualization system involved CAST personnel and the ERC's Dr. Robert Moorhead and Mr. Zhifan Zhu, an ERC Ph.D. student. Following his graduation, Dr. Zhu was hired by CAST as a Postdoctoral Assistant.

The MSU Center for International Security and Strategic Studies. Here CAST worked with Dr. Radvanyi in a workshop on "Japan-Russia-United States Study Group on Dumped Nuclear Waste in the Sea of Japan, Sea of Okhotsk, and North Pacific Ocean," which was held on 12-13 January 1995 in Biloxi, Mississippi.

The MSU Scientific and Technical Research Center. Here CAST worked with Dr. Roy Crochet in coordination of MSU activities at the Stennis Space Center.

The MSU Research Director's Council. The CAST Director was a member of the MSU council.

The Mississippi Research Consortium. This interdisciplinary interaction involved the awarding of two contracts to CAST (one from the Naval Oceanographic Office and one from the Naval Research Laboratory), issued as NASA delivery orders through the Consortium.

University of Southern Mississippi Cooperative Education Program. CAST also employed USM graduate students Mr. Michael S. Baer, Mr. Steven Payne, Mr. John Chambliss, and Mr. Edward Clark to assist in software engineering. Following their graduation, Mr. Baer and Mr. Payne were hired by CAST as Research Assistants.

Tulane University Department of Computer Science. CAST sponsored Dr. Fred Petry in a joint research effort with Gulf Weather Corporation under the DOD Small Business Innovative Research Program Phase I and Phase II.

University of Colorado. CAST was involved in a collaborative effort (no funding was exchanged) with Dr. Lakshmi Kantha to transition the CAST Model Evaluation System to Colorado for use with his tidal and ocean circulation models. CAST was also funded by ONR in a joint research project on Relocatable Models in Coastal Seas.

Oregon State University. CAST employed graduate student Mr. Alberto Mestas-Nunez to assist in ocean modeling applications.

Brandeis University. CAST employed undergraduate student Mr. Arun Sridharan to assist in software engineering applications.

University of Virginia. CAST hired Dr. Avichal Mehra as a postdoctoral assistant position to assist in ocean modeling.

Gulf Weather Corporation. CAST worked with this company in submitting a Phase II proposal under the Department of Defense Small Business Innovative Research Program for a Meta-Database for Ocean Imagery, which was the first SBIR project funded for 1995 in the State of Mississippi.

Naval Research Laboratory-Stennis Space Center, MS. CAST worked with Dr. Paul Martin in using DieCAST to model the Straits of Sicily and with Dr. Harley Hurlburt in coupling the DieCAST Gulf of Mexico model with the Naval Research Laboratory high resolution North Atlantic model. CAST is also collaborating with Dr. Steve Piacsek and has received funding to apply DieCAST to the North Atlantic Basin, with the model being run on SP-2 and Cray supercomputers. Also, Dr. Charles Barron will be using DieCAST to do some comparisons with the Princeton Ocean Model in Gulf of Mexico simulations in the LATEX region.

Naval Research Laboratory-Monterey, CA. CAST worked with Drs. Ted Tsui and Gary Love in the transition of CAST graphics, visualization, and weather briefing software to the Navy's Tactical Environmental Support System.

Planning Systems, Inc. CAST worked with this company in preparing a five-year proposal to support the Naval Research Laboratory Environmental Acoustics Program. This contract was awarded to PSI in late 1994 and CAST is a subcontractor in this effort.

The Electric Corporation of New Zealand. CAST researcher Dr. David Dietrich serves as a consultant to this corporation and uses the DieCAST model in environmental impact studies of hydro-electric power plant effects in the Doubtful Sound region.

William Carey College Interns. CAST sponsored Ms. Ann Lott, Ms. Maria Lindberg, and Mr. Shannon Ellis as Graphics Design Interns from William Carey College in Gulfport, MS. In this capacity, these individuals assisted in CAST graphics work, while simultaneously given the opportunity to enhance their experience in CAST software and hardware system.

WLOX-Television. CAST employed Ms. Debbie Baer, Art Director for WLOX and Graphics Arts Instructor at William Carey College, as a consultant in graphics and visual communications.

Consortium for Oceanographic Research and Education. CAST collaborated with Admiral James Watkins and Dr. Robert Spinrad of this Consortium called CORE whose purpose is to advance the science of oceanography. As a result of this meeting, Mississippi State University, with CAST, DIAL, and the ERC as interested participants, became a voting member of CORE. The CAST Director represents MSU at CORE meetings

Master Environmental Library. CAST worked with the Air Force Environmental Technical Applications Center, the Naval Research Laboratory, the Army Corps of Engineers Coastal Engineering Research Center, the Naval Oceanographic Office, the Argonne National Laboratory, and the Army Research Laboratory at the White Sands Missile Range in developing the Master Environmental Library for the Department of Defense.

Stennis Space Center Day, State Capital, Jackson, MS. CAST participated in the first Stennis Space Center Day at the Mississippi State Capitol. At this meeting CAST, in conjunction with the Naval Meteorology and Oceanography Command, the Naval Oceanographic Office, and the Army Corps of Engineers Coastal Engineer, demonstrated several software applications for the Governor and various members of the State Legislature.

Lawrence Livermore National Laboratory. CAST participated in discussions held in San Francisco to review with Naval Oceanographic Office, Army Corps of Engineers Coastal Engineering Research Center, and Lawrence Livermore researchers the present status and future plans for research transitions to the operational Navy.

Commander Naval Meteorology and Oceanography Command (CNMOC) Shallow Water Model Assessment Panel. The CAST Director was selected as a member of this panel to review the status of ocean modeling and to make recommendations on which models should be transitioned to the operational Navy.

Lockheed Corporation. CAST conducted liaison on computer networking and systems support at the Stennis Space Center with this Corporation.

Naval Research Laboratory Ocean Sensing and Prediction Division. CAST also provided computer networking and systems support at the Stennis Space Center under contract with this Laboratory.

Australian Bureau of Meteorology. Dr. Brian Sanderson in Melbourne is collaborating with CAST in using DieCAST to run simulations in the Australian Current and the Tasman Sea.

New Zealand Electric Company. This company is collaborating and funding CAST's Dr. David Dietrich for modeling studies of coastal areas using DieCAST.

University of Otago. The Marine Science Department of this New Zealand University (Dr. Philip Mladinov, Chairman) is collaborating with CAST on DieCAST model applications locally.

Naval Postgraduate School. Dr. Robert Haney is collaborating with CAST and funding Dr. Dietrich in modeling the California Current using DieCAST. In addition, Dr. Alvaro Viudez is currently running DieCAST in the Western Mediterranean (Alboran Basin) to study the dynamics of a major semi-permanent anticyclonic gyre.

Bedford Institute of Oceanography. Dr. Daniel Wright in Nova Scotia is currently employing DieCAST for eddy resolving North Atlantic climate studies.

Memorial University. Dr. Richard Greatbatch in Newfoundland in using DieCAST for high resolution modeling of the Labrador Sea and the Newfoundland/Labrador Shelf.

NOAA Great Lakes Environmental Research Laboratory. Drs. Dimitry Beletsky, William O'Connor, and David Schwab are collaborating with CAST in conducting numerical simulations of internal Kelvin Waves and coastal upwelling events in the Great Lakes.

McGill University. Dr. Charles Lin is collaborating with CAST in the use of DieCAST for global climate research.

Dalhousie University. Dr. Keith Thompson is collaborating with CAST to add data assimilation to DieCAST for applications in Canadian waters.

British Petroleum Exploration. CAST has received inquiries from this company regards support for the prediction of currents in the Gulf of Mexico as it applies to oil rigs.

#### OTHER WORKSHOPS AND MEETINGS ATTENDED BY CAST

Name	Title	Dates/Location
J.H.Corbin R. Krishnamagaru L.A. Yeske H. Anand M.S. Foster A. Matiyevsky C. Cesario	Presentation and Demonstration by Dr. Bob Zalkan of the Naval Research Laboratory on the Visual Interface for Space and Terrestrial Analysis (VISTA) System	4 October 1994 Stennis Space Ctr, MS
L. Yeske R. Crochet	Meeting with Dr. Kelly Tucker of MSU Center for Health and Safety	12 October 1994 Stennis Space Ctr, MS
CAST Staff	Meeting with Ms. Ann Bell, MSU Employee Benefits Manager	18 October 1994 Stennis Space Ctr, MS
L.Yeske	MSU Faculty Research Awards Luncheon	29 November 1994 Mississippi State, MS
J. Corbin L. Yeske	MSU Research Director's Council Meeting	8 December 1994 Mississippi State, MS
J. Corbin L. Yeske	MSU Director of Social Sciences Research Center Meeting	13 December 1994 Stennis Space Ctr, MS
J. Corbin L. Yeske	6.4 Program Review of CAST Software Transitions to Naval Oceanographic Office	3-6 January 1995 Stennis Space Ctr, MS
M.S. Foster V. Anantharaj	Japan-Russia-United States Study Group on Dumped Nuclear Waste in the Sea of Japan, Sea of Okhotsk and the North Pacific Ocean	12-13 January 1995 Biloxi, MS

<u>Name</u>	<u>Title</u>	<u>Dates/Location</u>
J. Corbin R. Krishnamagaru	6.4 Program Review of CAST Software Transitions to Fleet Numerical Oceanography and Meteorology Center and TESS	16-20 January 1995 Monterey, CA
V. Anantharaj M.S. Baer S. Payne	UNIX Training Courses	17-20 January 1995 New Orleans, LA
J.H. Corbin R. Krishnamagaru V. Anantharaj	Development of a Prototype Master Environmental Library	7-8 February 1995 Scott Air Force Base, Illinois
L.A. Yeske	Offsite Overhead Discussions with MSU Indirect Cost Consultant	8-9 February 1995 Mississippi State, MS
J.H. Corbin R. Krishnamagaru V. Anantharaj	Development of a Prototype Master Environmental Library	9-10 February 1995 Army Coastal Engr Research Center, Vicksburg, MS
L.A. Yeske H. Anand	Stennis Space Center Days for the Governor and State Legislature	13-14 February 1995 Capital-Jackson, MS
J.H. Corbin R. Krishnamagaru V. Anantharaj	Workshop on the Development of a Master Environmental Library	13-14 February 1995 Stennis Space Ctr, MS
J.H. Corbin L.A. Yeske R. Moorhead H.Anand	Development of the Unified Air-Sea Visualization System Progress Meeting	21 February 1995 Stennis Space Ctr, MS
J.H. Corbin L.A. Yeske M.C. Ray	Meeting with President of the Consortium for Ocean Research and Education, Admiral James Watkins and Dr. Richard Spinrad	22 February 1995 Stennis Space Ctr, MS

<u>Name</u>	<u>Title</u>	<u>Dates/Location</u>
J.H. Corbin D. Dietrich R. Moorhead H. Anand V. Anantharaj	Meeting of Navy Ocean Modeling Program Principal Investigators	22 March 1995 Stennis Space Ctr, MS
J.H. Corbin L.A. Yeske CAST Staff	Interview Mr. Krishna Achutarao for Postdoctoral Assistant Position	23 March 1995 Stennis Space Ctr, MS
V. Anantharaj	Data Assimilation and Model Evaluation Experiment Workshop	23-24 March 1995 Stennis Space Ctr, MS
J.H. Corbin	Meeting on Navy Ocean Modeling with Technical Director, Naval Oceanographic Office	6 April 1995 Stennis Space Ctr, MS
J.H. Corbin L.A. Yeske V. Anantharaj	Meeting William Carey College Reps John Armstrong and Johnathon Howard, and Ann Baer of WLOX-TV on Student Interns	12 April 1995 Stennis Space Ctr, MS
J.H. Corbin A. Matiyevsky R. Krishnamagaru	Planning Meeting on the Weather Watch Research Program with the Naval Research Laboratory	18-19 April 1995 Stennis Space ctr, MS
L.A. Yeske H. Anand	Meeting on ADCIRC Model Storm Surge Applications with NAVOCEANO and CERC	21 April 1995 Stennis Space Ctr, MS
J.H. Corbin R. Krishnamagaru V. Anantharaj	Development of a Master Environmental Library	24-26 April 1995 Argonne National Laboratory, Illinois
L.A. Yeske M.S. Baer	Meeting on Master Environmental Library Data Provider Needs	25 April 1995 Stennis Space Ctr, MS
J.H. Corbin L. A. Yeske	Meeting on Joint Issues/Funding regards on Present and Future Transitions to NAVOCEANO	1-4 May 1995 Livermore Natl Lab San Francisco, CA

Name	Title	Dates/Location
J.H. Corbin L.A. Yeske	Meeting with Chairman of the Oceanography Department, Naval Postgraduate School	9 May 1995 Stennis Space Ctr, MS
J.H. Corbin	Meeting of the CNMOC Shallow Water Model Assessment Panel	15 May 1995 Stennis Space Ctr, MS
J.H. Corbin R. Krishnamagaru V. Anantharaj	Workshop on Development of a Master Environmental Library	23-24 May 1995 White Sands Missile Range, NM
L.A. Yeske E. Lott M. Wilson	Banner System Training Course for MSU Accounting	24-25 May 1995 Mississippi State, MS
M.S. Foster R. Krishnamagaru	Meeting with CDR David Markham and Dr. Ed Harrison of SPAWARS on 6.4 Transitions to the Navy	25 May 1995 Stennis Space Ctr, MS
L.A. Yeske CAST Staff	Interview Dr. Avichal Mehra for Postdoctoral Assistant Position	30 May 1995 Stennis Space Ctr, MS
J.H. Corbin	Meetings with NRL and FNMOC Program Managers on CAST 6.4 Transitions to the Navy	30-31 May 1995 Monterey, CA
H. Anand	Meeting with Naval Postgraduate School, FNMOC, and NRL Personnel on CMES, ISIS BROWSER, and ENVIS Transitions	13-15 June 1995 Monterey, CA
V. Anantharaj	Meeting with Dr. Lakshmi Kantha on Relocatable Models Project	14-16 June 1995 Boulder, CO
J.H. Corbin V. Anantharaj R. Krishnamagaru	Planning Meeting with NRL Personnel to Finalize MEL Regional Site Software Design	20-22 June 1995 Monterey, CA

<u>Name</u>	<u>Title</u>	<u>Dates/Location</u>
J.H. Corbin	Planning Meeting with Gulf Weather Corporation on Implementation of DOD SBIR Phase II Contract	24 June 1995 Stennis Space Ctr, MS
J.H. Corbin L.A. Yeske V. Anantharaj	Meeting with Ms. Ann Lott, WLOX-TV Channel 13 Biloxi, MS on Graphics Student Intern Program	29 June 1995 Stennis Space Ctr, MS
J.H. Corbin L.A. Yeske M.S. Foster E.G. Lott	Ceremony on Merger of the USM Center for Ocean and Atmospheric Modeling with USM Center for Marine Sciences	30 June 1995 Stennis Space Ctr, MS
J.H. Corbin L.A. Yeske	SPAWARS Tactical Environmental Support System Project Review	6 July 1995 Stennis Space Ctr, MS
J.H. Corbin	SPAWARS Visualization and Graphics Applications Meeting	10-11 July 1995 Monterey, CA
J.H. Corbin L.A. Yeske M.S. Foster	CAST Model Evaluation System, ENVIS, and Weather Watch with NAVOCEANO Warfighting Support Center Personnel	17 July 1995 Stennis Space Ctr, MS
D. Baer J. Howard M. Lindberg S. Ellis	Meeting with MSU Engineering Research Center Personnel on Electronic/Digital Media for Visual Communications	18 July 1995 Mississippi State, MS
J.H. Corbin L.A. Yeske	Seminar by Dr. David Banks of MSU on Visualizing a Turbulent Flow by Vortex Structures	18 July 1995 Stennis Space Ctr, MS
J.H. Corbin L.A. Yeske F. Schatzle	Planning Meeting with Commander David Titley of NAVOCEANO on DOD SBIR Contract for a Metadata Database for Automated Oceanographic Imagery	19 July 1995 Stennis Space Ctr, MS

Name	Title	Dates/Location
J.H. Corbin V. Anantharaj R. Krishnamagaru	Meeting on Master Environmental Library LS Implementation	19-21 July 1995 Las Cruces, NM
D.E. Dietrich	Discussions on Future Collaboration in Ocean Modeling at Los Alamos National Laboratory Center for Nonlinear Study Conference	25 July 1995 Los Alamos, NM
J.H. Corbin R. Krishnamagaru V. Anantharaj	Meeting with NRL Chuck Stein on MEL Progress	25 July 1995 Stennis Space Ctr, MS
J.H. Corbin	Discussions with Mr. John Ellis of Naval Research Laboratory on Tactical Oceanography Wide Area Network Contract Termination	26 July 1995 Stennis Space Ctr, MS
V. Anantharaj	Meeting with Army Research Laboratory Personnel on MEL Data Requirements	26-28 July 1995 White Sands, NM
J.H. Corbin L.A. Yeske F. Schatzle	Meeting with Gulf Weather Corp. on DOD SBIR Contract for a Metadata Database for Automated Oceanographic Imagery	4 August 1995 Stennis Space Ctr, MS
V. Anantharaj D. Baer A. Matiyevsky	Siggraph '95 Annual Convention of the Association for Computing Machinery Special Interest Group on Computer Graphics	6-11 August 1995 Los Angeles, CA
J.H. Corbin	Status Meeting with MSU Vice President and Associate Vice President for Research	16 August 1995 Mississippi State, MS
L.A. Yeske	Meeting with Dr. James Meredith of Center for Higher Learning on New Course Offerings	17 August 1995 Stennis Space Ctr, MS

Name	Title	Dates/Location
D.E. Dietrich	Meeting Dr. Brian Sanderson, Australian Bureau of Meteorology on Modeling of Australian Current and Tasman Sea	28-31 August 1995 Albuquerque, NM
J.H. Crobin R. Krishnamagaru	Master Environmental Library Third Quarter Workshop	5-7 September 1995 Monterey, CA
D.E. Dietrich	Meeting Dr. Malcolm Bowman, State University of New York on Modeling of Coastal New Zealand using DieCAST	11-22 September 1995 Albuquerque, NM
R. Krishnamagaru D. Goff	LISA '95: The 9th Annual Systems Administration Conference	17-22 September 1995 Monterey, CA
J.H. Corbin CAST Staff	Interview Ms. Dorlisa Hummel for Research Assistant Position	18-19 September 1995 Stennis Space Ctr, MS
J.H. Corbin C. Abbott H. Anand	Planning Meeting with NAVOCEANO WSC Personnel on WAM Quality Control Research	19 September 1995 Stennis Space Ctr, MS
D.E. Dietrich	Meeting Dr. Philip Mladinov, Otago University of New Zealand on Modeling with DieCAST	25-29 September 1995 Albuquerque, NM
A. Matiyevsky	Meeting with NRL and FNMOC Personnel on Software Transitions	25-29 September 1995 Monterey, CA
V. Anantharaj	Meeting on Master Environmental Library Design with NRL Personnel	28-29 September 1995

## CAST PROPOSALS SUBMITTED AND CONTRACTS AWARDED

	<u>To</u>	<u>Title</u>	<u>Submitted</u>	<u>Amount Requested</u>	<u>Amount Awarded</u>
a..	Naval Research Laboratory Code 3250, Bldg 1007 Stennis Space Center, MS	PI: J.H. Corbin Tactical Oceanography Wide Area Network Support	4 Jan 94	\$92,317	\$92,317 9 May 94
b..	Naval Research Laboratory Code 3250, Bldg 1007 Stennis Space Center, MS	PI: J.H. Corbin Tactical Oceanography Wide Area Network Support Option F-NIDAS C	4 Jan 94	\$13,496	\$13,496 30 Sep 94
c.	Naval Research Laboratory Code 3250, Bldg 1007 Stennis Space Center, MS	PI: J.H. Corbin Tactical Oceanography Wide Area Network Support Option G	4 Jan 94	\$98,781	Not Awarded to CAST
d.	Army Coastal Engineering Research Center, Vicksburg	PI: J.H. Corbin Upgrade GUI for Joint LOTS Real Time Wave F/C System via NRL TOWAN Option H	23 Mar 94	\$30,057	\$30,057 29 Jul 94
e.	Army Coastal Engineering Research Center, Vicksburg	PI: J.H. Corbin Upgrade GUI for Coastal Eng Data Retrieval via TOWAN Option I	23 Mar 94	\$22,097	Not Awarded to CAST
f.	Office of Naval Research Navy Ocean Modeling and Prediction Program Arlington, VA	Co-PIs: D.Dietrich and A. Mestas-Nunez High Resolution Coastal Model Studies	22 Apr 94	\$612,943	\$400,000 17 May 94
g.	Office of Naval Research Navy Ocean Modeling and Prediction Program Arlington, VA	Co-PIs: J.H. Corbin, R. Moorhead and B. Hamann For A unified Air-Sea Visualization System	26 Apr 94	\$456,606	\$456,606 17 May 94
h.	Office of Naval Research Navy Ocean Modeling and Prediction Program Arlington, VA	Co-PIs: V. Anantharaj and L. Kantha, Relocatable Numerical Models of Marginal, Semi-Enclosed, and Coastal Seas	26 Apr 94	332,129	\$272,000 17 May 94
i.	Office of Naval Research Navy Ocean Modeling and Prediction Program Arlington, VA	Co-PIs: V. Anantharaj and M. Foster, MSU CAST Participation in DAMEE North Atlantic Basin	26 Apr 94	423,590	\$120,000 17 May 94
j.	Office of Naval Research Navy Ocean Modeling and Prediction Program Arlington, VA	PI: J. Corbin Software Transitions to NAVOCEANO and TESS	26 Apr 94	652,544	\$350,000 17 May 94

<u>To</u>	<u>Title</u>	<u>Submitted</u>	<u>Amount Requested</u>	<u>Amount Awarded</u>
k. Naval Research Laboratory Environmental Acoustics via Planning Systems, Inc. Slidell, LA	PI: J. Corbin Environmental Acoustics Support - CAST is a Subcontractor to PSI	16 May 94	134,495	\$134,495 15 Aug 94
l. DOD Small Business Innovative Research Program via Gulf Weather Corporation Stennis Space Center, MS	PI: J. Corbin Metadata Base for Automated Oceanographic Imagery Information Phase II	16 May 94	331,275	\$315,033 23 May 95
m. Naval Oceanographic Office Code DOST Stennis Space Center, MS	PI: D. Krishnamagaru Navy Interactive Data Analysis System Development-Phase II	3 June 94	29,500	\$29,500 17 Jun 94
n. Office of Naval Research Navy ocean Modeling and Prediction Program Arlington, VA	Co-PI's: R. Krishnamagaru, J. Hodges, and S. Bridges Development of an Object-Oriented Database System	14 July 94	\$415,796	Not Awarded to MSU
o. Naval Oceanographic Office Code DOST Stennis Space Center, MS	PI: R. Krishnamagaru Navy Interactive Data Analysis System Development--Phase II	14 July 1994	\$99,100	\$99,100 1 Aug 94
p. Department of Defense Washington, DC (AASERT Program)	PI: R. Krishnamagaru Graduate Student Support for the Navy Interactive Data Analysis System	25 Aug 94	\$171,717	Not Awarded to CAST
q. Department of Defense Washington, DC (AASERT Program)	PI: J. Corbin Graduate Student Support for Software Transitions to the Operational Navy	27 Sept 94	\$107,748	Not Awarded to CAST
r. Naval Oceanographic Office Code DOST Stennis Space Center, MS	PI: R. Krishnamagaru Naval Interactive Data Analysis System Development-Phase III	15 Nov 1994	\$75,500	\$75,500 21 Dec 94
s. Naval Research Laboratory Code 3250, Bldg 1007 Stennis Space Center, MS	PI: J.H. Corbin Tactical Oceanography Wide Area Network Support Option J-Development of MEL	15 Jan 95	\$60,334	\$60,000 28 Mar 95
t. Naval Research Laboratory Code 3250, Bldg 1007 Stennis Space Center, MS	PI: J.H. Corbin Tactical Oceanography Wide Area Network Support Options K-Software Demonstrations for Option H	15 Jan 95	\$7,900	\$7,900 28 Mar 95

<u>To</u>	<u>Title</u>	<u>Submitted</u>	<u>Amount Requested</u>	<u>Amount Awarded</u>
u. Naval Research Laboratory Code 7320, Bldg 1103 Stennis Space Center, MS	PI: D.E. Dietrich Modeling with DicCAST in the North Atlantic Basin	20 Mar 95	\$24,500	\$24,400 22 June 95
v. Naval Research Laboratory Code 3250, Bldg 1007 Stennis Space Center, MS	PI: J.H. Corbin TOWAN	21 Apr 95	\$821,434	Not Awarded to CAST
w. Naval Research Laboratory Code 3250, Bldg 1007 Stennis Space Center, MS	PI: J.H. Corbin Development of the Master Environmental Library	27 Apr 95	\$1,369,263	\$1,369,263 22 Sep 95
x. Naval Research Laboratory Code 7320, Bldg. 1103 Stennis Space Center, MS	PI: C. Vosbein Computer Service Support	13 Jul 95	\$31,897	\$31,897 29 Aug 95
y. Waterways Exp Station Coastal Eng Res Center Code CR-O, Vicksburg, MS	PI: Dr. Harsh Anand Development of ADCIRC Model Scripts	18 Jul 95	\$15,000	Pending
z. University of Texas Applied Res Laboratory Austin, TX	PI: M.S. Foster Conduct Training Course in NEONS	26 Jul 95	\$4,486	Pending
aa. Naval Research Laboratory Code 7320, Bldg 1103 Stennis Space Center, MS	PI: M.S. Foster Development of Prototype Wave Model Quality Control System	8 Aug 95	\$22,000	Pending
ab. Naval Research Laboratory via the Mississippi Research Consortium and NASA Stennis Space Center, MS	PI: J.H. Corbin Ocean Database Management Systems (NIDAS)	5 Sept 95	\$699,971	Pending
ac. Naval Research Laboratory Monterey, CA	PI: J.H. Corbin TESS/NITES Software Tools	5 Sept 95	\$700,000	Pending
ad. Naval Oceanographic Office Stennis Space Center, MS	PI: J.H. Corbin Installation of CAST Model Evaluation System at WSC	5 Sept 95	\$25,000	\$25,000 25 Sep 95

## ACKNOWLEDGEMENTS

This research was supported by the Department of the Navy, Office of the Chief of Naval Research under Research Grants N00014-95-1-0186, N00014-95-1-0218, N00014-95-1-0293, N00014-95-1-0303 with Mississippi State University; Office of Naval Research Grant N00014-95-1-0068 under Subcontract USM-0228251110-A10 to the University of Southern Mississippi; Naval Research Laboratory Contract N00014-92-C-6032; NASA Contract NAS13-564 Delivery Order 11 with the Naval Oceanographic Office; and a Subcontract with Gulf Weather Corporation under the

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We would also like to thank the scientific, technical, and support personnel (permanent, research affiliates, students, and consultants) who were directly funded by CAST through this Research Grant for their superb performance. These individuals included:

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# REPORT DOCUMENTATION PAGE

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